EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION
RELATING TO THE REINSTALLATION OF ORIGINAL SPENT FUEL RACKS
AT THE DIABLO CANYON NUCLEAR POWER PLANT, UNIT 1
FACILITY OPERATING LICENSE DPR-80
DOCKET NO. 50-275
PACIFIC GAS AND ELECTRIC COMPANY

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ENCLOSURES:

1. U.S. Nuclear Regulatory Commission, "Meeting Summary - Reinstallation of Original Spent Fuel Racks Into Unit 1 Fuel Pool", by H. Schierling, dated September 18, 1986 (Reference 5).

2. U.S. Nuclear Regulatory Commission, "Meeting Summary - Reinstallation of Original Spent Fuel Racks Into Unit 1 Fuel Pool (Second Meeting)", by H. Schierling, dated October 1, 1986 (Reference 6).

3. Letter from J. D. Shiffer (PG&E) to S. A. Varga, (NRC): "Spent Fuel Storage Racks", DCL 86-285, dated September 26, 1986 (Reference 18).

1.0 INTRODUCTION AND BACKGROUND

At the request of the NRC Region V Office (Ref. 1) the NRC Office of Nuclear Reactor Regulation (NRR) has performed an evaluation of changes to the original spent fuel racks for Diablo Canyon Unit 1 that were reinstalled into the Unit 1 spent fuel pool. The Pacific Gas and Electric Company (PG&E), licensee for the Diablo Canyon facility, has performed these changes under the provisions of 10 CFR 50.59. Related to this, in an "Application for an Order Prohibiting Onsite Storage of Radioactive Spent Fuel at Unit 1, Diablo Canyon and for Public Hearing" (Ref. 2) filed with the NRC on September 16, 1986 on behalf of the San Luis Obispo Mothers for Peace and the Sierra Club, Santa Lucia Chapter, San Luis Obispo ("Intervenors") the following three issues regarding the reinstallation of the original spent fuel racks into the Unit 1 spent fuel pool were raised:

1. "the potential for leakage of the liner as a result of the welds;"
2. "the difference in physical response of the rack between welding the racks to the liner rather than bolting them through the liner into the floor; and"
3. "the possible instability of the racks in a seismic event due to the inability to weld properly sections of the rack's base."

The issues are based on affidavits by Dr. Richard B. Ferguson and Mr. Phillip W. B. Niles regarding the reinstallation of the original spent fuel racks and in particular regarding the method of anchoring the racks to the spent fuel pool foundation by welding as compared to the original means of attachment, i.e. bolting. These issues are raised in paragraphs 16, 17, and 18 of the Ferguson affidavit and paragraphs 3, 4, and 5 of the Niles affidavit.

This evaluation also addresses the adequacy of certain original welds to the original spent fuel rack structures as discussed in Section 6 of this report. On September 24, 1986 the NRC Region V office requested the NRR staff to evaluate the adequacy of three original welds, the actual dimensions of which were found to be less than recorded on as-built drawings (Ref. 17).

In early June the licensee, in anticipation of using the new racks, had removed the original racks and prepared the spent fuel pool for installation of the new racks, which consisted primarily of removing existing anchor bolts as discussed in detail below. The new racks had been fully installed by late June. When the use of the new, high density, freestanding racks, as contemplated by License Amendment Nos. 8 and 6 of May 30, 1986 for Diablo Canyon Units 1 and 2, respectively (Ref. 3) became uncertain as a result of the Order of July 2, 1986 by the U.S. Court of Appeals (Ref. 4) the licensee evaluated the reinstallation of the original racks.

As a result of its evaluation of the original racks and their method of reinstallation the licensee determined that the following four changes to the original racks would be required:

1. anchoring the racks to the pool foundation by welding the anchor-bolt-bearing plates directly to the embed plates instead of using bolts welded to the embed plates as in the initial installation;
2. reinforcement of cross braces of rack frame structures;
3. addition of weld material to one corner of the Rack 8 frame structure; and
4. repair of one strap (i.e. lacing) on one fuel cell in Rack 1.

Each of these changes is described in detail in Section 2 of this report and the staff's detailed evaluation is presented in Section 5.

The licensee also performed an evaluation to determine if these changes could be made under the provisions of the Commission's regulations in 10 CFR 50.59, that is, without prior review and approval by the NRC. This is discussed in further detail in Section 4. The licensee concluded that the changes could be made under 10 CFR 50.59. The new, high density, freestanding racks were removed and re-installation of the original racks, after appropriate preparation and changes, commenced on September 5, 1986. The installation was completed on September 15, 1986.

Since about mid July 1986 the NRC staff was aware of the licensee's intent to reinstall the original racks in the event that the new racks could not be used for the imminent first offloading of spent fuel from Unit 1. The licensee had informed the staff that some changes had to be made for the reinstallation of the original racks, primarily with regard to the means of attachment, but in the licensee's view, these changes would be made in accordance with the provisions of 10 CFR 50.59. Because of the heightened interest by the Intervenors and the NRC in matters relating to the storage of spent fuel at the Diablo Canyon Plant, on about September 3, 1986 the NRC staff decided to review the licensee's evaluation required for the 10 CFR 50.59 determination. On September 5 the licensee provided information to the NRC Resident Inspector at the Diablo Canyon Plant and to the NRC Project Manager in NRR. The staff discussed the information with the licensee in a conference call on September 8 and raised a number of questions. These were discussed in a meeting in Bethesda, Maryland as documented in the NRC meeting summary report dated September 18, 1986 (Ref. 5). At the request of the staff, the licensee, in a submittal dated September 17, 1986 (Ref. 8) provided a more detailed description of the changes required for reinstallation of the original racks and an expanded evaluation of the changes with respect to the requirements in 10 CFR 50.59. In a second meeting with the licensee from September 19 through September 23 in Bethesda, Maryland, the staff discussed issues in further detail and conducted an indepth audit of the licensee's design calculation packages, including criteria, assumptions, analyses and drawings (Ref. 6).

Because of their extensive citation in this evaluation, in particular with respect to the use of figures for clarification purposes, the following three references have been attached to this report as enclosures:

Reference 5: NRC Summary of Meeting on September 10, 1986 (dated September 18, 1986) as Enclosure 1.

Reference 6: NRC Summary of Meeting on September 19 to 23, 1986 (dated October 1, 1986) as Enclosure 2.

Reference 18: PG&E letter DCL 86-285 (dated September 26, 1986) as Enclosure 3.

2.0 DESCRIPTION OF RACK CHANGES

2.1 Anchoring of Racks

The original method of installation of the racks is shown in Figure 18 of Enclosure 3. Four anchor-bolt-bearing plates, also called "feet", were welded to each rack at the bottom, one bearing plate at each corner of each rack. The bearing plate was fastened to the pool foundation with a bolt, 1 inch in diameter, which was welded to an anchoring system that is an integral part of the pool liner and structure. Specifically, the bolt was centered in a 2 1/2 inch diameter hole in the embed plate and welded with a 1/4 inch fillet weld, around its circumference at the end, to a 3 1/2 inch square plate, 3/8 inch thick. This plate in turn

was welded with a 3/16 inch fillet weld to the embed plate, which is a square plate, 8 inches at the side and 3/4 inch thick. The embed plate is butt-welded to the 1/4 inch thick pool liner. The embed plate is anchored into the concrete pool floor with eight Nelson studs, 7/8 inch in diameter and approximately 8 inches long. The eight Nelson studs are welded to the embed plate, with three studs on each side of the plate. Thus, the original rack installation, while using bolts as an intermediate element to transfer loads into the pool foundation, used a weld to transfer the loads from the bolts into the embed plate anchoring system.

The new high density racks are freestanding and, therefore, do not require the 1 inch diameter mounting bolts; these bolts would also interfere with the installation of the new racks. Therefore, in preparation for the installation of the new racks, the mounting bolts were cut off with a grinding disc and the annular space between the root of the bolt and the 2 1/2 inch diameter hole was filled with weld material and then ground flush with the top of the embed plate. Except for this, the embed plate and the anchoring of the embed plate to the pool foundation were not changed in any form for the reinstallation of the racks.

The eight original racks were reinstalled in the original configuration, except that the method of mounting them to the pool foundation was changed. Instead of anchoring the racks by bolts, which in turn had been welded to the embed plates, the racks were welded directly to the same embed plates without any changes in

the anchoring of the plates to the concrete foundation. Based on the re-analysis of the mounting (see Section 5) it was determined that a 5/8 inch fillet weld, 10.5 inches in length, or equivalent, is required to transmit the load into the embed plate anchoring system. In order to meet this requirement and to account for the actual as-built conditions the anchor-bolt-bearing plates on the eight racks were partially cut off as shown on Figure 9 of Enclosure 3 resulting in a fillet weld, 7 inches long and of 7/8 inch size. (Initially the anchor-bolt-bearing plates on Rack 1 had not been cut off and welded to the embed plates; subsequently these plates were cut off as was done for the other racks). The as-built welds were made under applicable quality controls, were inspected and determined to meet the requirements discussed above.

2.2 Bracing Reinforcement

The original eight racks were designed and built as a frame structure with two sets of cross braces on each side face of the racks, as shown on Figure 10 of Enclosure 3. One of the braces of each cross was continuous, the other discontinuous, i.e. it was cut at the intersection. At the intersection the continuous and discontinuous braces were welded to a back plate. As a result of the re-analysis performed prior to the reinstallation of the racks it was determined that reinforcement of the discontinuous brace was required as discussed in Section 5. A bar, 2 inches wide, 1 1/4 inches thick and at least 16 inches long was symmetrically welded to the top of the discontinuous brace, across the continuous brace, with a 5/16 inch fillet weld, at least 8 inches long.

2.3 Rack 8 Gusset Plate Weld

An additional weld was added to the connection of one brace to a gusset plate on the bottom of one corner of Rack 8. This weld had been made at the other connections on Rack 8 and at all other racks. As discussed in Section 5, the original as-installed weld met the loads in the original calculations but not the new loads determined in the re-anaylsis based on a more conservative fuel rack modeling assumption.

2.4 Rack 1 Strap Repair

During the removal of the original racks the top strap on one fuel cell of Rack 1 was damaged. The damaged strap was removed and a new strap was welded to the fuel cell approximately 3 inches from the original location in the same manner as the original strap.

3.0 <u>EVALUATION OF THREE ISSUES</u>

The staff has evaluated the following issues identified by the Intervenors (Ref. 2) regarding the reinstallation of the original spent fuel racks into the Unit 1 pool:

1. "The potential for leakage of the liner as a result of the welds."

As discussed in Section 2 of this report, the reinstallation of the racks is not by welding the racks to the 1/4 inch thick pool liner itself but by welding the anchor-bolt-bearing plates to the 3/4 inch thick embed plates which are anchored into the pool foundation and which are butt-welded to the liner. As discussed in Section 5, this does not create any different loads on the liner than the previous installation of securing the racks by bolts which themselves were welded to the embed plates. The staff concludes there is no potential for leakage as a result of these welds.

2. "The difference in physical response of the rack between welding the racks to the liner rather than bolting them through the liner into the floor."

As discussed at Item 1 above and in Section 2 of this report, in the original installation and in the reinstallation, the racks are attached to embed plates which are anchored into the pool foundation. There is no change in the anchoring system between the original installation and the reinstallation. There is a difference in the mounting of the anchor-bolt-bearing plates to the embed plates; originally the bearing plates were secured by bolts that were welded to the embeds, while in the reinstallation, they are welded directly directly to the same embeds.

The licensee, in its re-analysis as discussed in detail in Section 5 of this report determined, on the basis of now assuming a flexible fuel rack instead of a rigid fuel rack as had originally been assumed, that the loads on the anchoring system are higher than originally had been calculated. As a result, the calculated physical response between the originally installed racks and the reinstalled racks did change. However, this change is not the result of the change in the method of installation but a result of the method of re-analysis. The staff concludes there is no difference in physical response of the racks as a result of the difference in the method of anchor-bolt-bearing plate installation.

3. "The possible instability of the racks in a seismic event due to the inability to weld properly sections of the rack's base."

The licensee built a model to determine adequate accessibility to the bottom of the racks in order to make the necessary welds (Ref. 9, Section 5; Ref. 5, and Ref. 6) The entire welding process was pre-established and controlled. All welding activities and welds were inspected and documented in accordance with approved procedures. An NRC Resident Inspector audited the welding activities and inspected each of the 32 anchor-bolt-bearing welds for the eight racks. The throat area of one of the welds was determined to be short 1/8 inch in the vertical direction and to be long 1/8 inch in the horizontal direction thus meeting the requirement of minimum cross sectional throat area. The results of the NRC inspection effort will be documented in a NRC Region V Inspection Report, to be issued in the near future (Ref. 10). The staff concludes, based

on the above that the welds between the anchor-bolt-bearing plates and the embed plates were performed properly and in accordance with applicable codes and standards and therefore do not cause possible instability of the racks in a seismic event. Further details of the NRC inspection effort are addressed in Section 6 for this report.

The staff concludes, based on its evaluation of the above three postulated events with respect to the changes to the racks and the change in method of the rack installation, that these do not cause the postulated events.

4.0 CONSIDERATION OF 10 CFR 50.59

The major issue raised in the Ferguson and Niles Affidavits is the method of anchoring the reinstalled racks to the pool foundation by means of welding with respect to the anchoring requirements as set forth in the licensee's Final Safety Analysis Report (FSAR), Update Revision 1, September 20, 1985 (Ref. 7) and in the operating licenses for Units 1 and 2, including the Technical Specifications.

The design bases, description, and safety evaluation of the spent fuel storage pool and racks are provided in Sections 9.1.2.1, 9.1.2.2 and 9.1.2.3, respectively, of the licensee's Final Safety Analysis Report (FSAR).
The only references in the FSAR to the anchoring of the racks by bolts to the floor is the note on Figures 9.1-1 and 9.1-2: "Anchor bolt bearing plate (typ.) secured to floor by 1" bolt at four corners."

The operating licenses for Diablo Canyon Units 1 and 2, including their combined Technical Specifications do not include a requirement that the racks be bolted to or be secured to the pool floor in any form, nor do the Bases to the Technical Specifications include any reference to the mounting of spent fuel racks.

As stated in 10 CFR 50.59 (a)(1), the licensee may make changes to the facility as described in the safety analysis report without prior Commission approval unless the proposed change involves (1) a change in the Technical Specifications incorporated in the license or (2) an unreviewed safety question.

As discussed above, none of the changes identified by the licensee involves a change in the Technical Specifications. Therefore, with respect to this aspect of 10 CFR 50.59, all of these changes can be made without prior Commission approval.

Based on its review and evaluation of the information provided by the licensee, the staff finds that the repair of the strap on Rack 1 and the addition of weld material to the weld on Rack 8 clearly are not changes to the facility as described in the FSAR but are changes made to meet the design as presented in the FSAR and the licensee's internal design documents. Therefore, the staff finds that it is acceptable for the licensee to make these changes.

Regarding the consideration of any of these changes in terms of whether an "unreviewed safety question"is presented, 10 CFR 50.59 (a)(2) states that a proposed change shall be deemed to involve an unreviewed safety question:

(i) if the probability of occurrence or the consequences of an accident or malfunction of equipment important to safety previously evaluated in the safety analysis report may be increased; or

(ii) if a possibility for an accident or malfunction of a different type than any evaluated previously in the safety analysis report may be created; or

(iii) if the margin of safety as defined in the basis for any technical specification is reduced.

The licensee has evaluated the four changes with respect to these three criteria as documented in the letter of September 17, 1986 (Ref. 8) and amended by letter of September 23, 1986 (Ref. 9). The staff has reviewed licensee's evaluation and conducted extensive audits and evaluations of the licensee's internal documentation, including design calculations, assumptions and revised analyses. The results of this effort are presented in Section 5 of this report. This evaluation was performed to determine if any of the changes would affect in any form the intended safety function of the spent fuel racks and if the racks with the changes meet the original FSAR criteria for the racks.

The staff has reviewed the changes to the racks and the method of installation with respect to postulated and previously analyzed accidents involving criticality, fuel damage, and release of radioactivity considerations, in particular with respect to the potential for damage to the spent fuel pool liner, as contemplated in the Ferguson Affidavit (paragraphs 16, 17 and 18) and Niles Affidavit (paragraphs 3, 4 and 5). Based on its review of the licensee's evaluation and based on its

own evaluation of the licensee's documentation, including calculations, as set out in Section 5, the staff concludes that none of the changes to the racks, including the method of reinstallation.

1. increases the probability of occurrence or the consequences of an accident or malfunction of equipment important to safety previously evaluated in the safety analysis report;
2. creates a possibility for an accident or malfunction of a different type than any evaluated previously in the safety analysis report; or
3. reduces the margin of safety as defined in the basis for any technical specification.

Therefore, the staff concludes that these changes do not constitute an unreviewed question and were appropriately evaluated by the licensee in accordance with the provisions of 10 CFR 50.59.

5.0 DETAILED EVALUATION OF RACK CHANGES

5.1 Introduction

PG&E has revised certain structural details of the original low density spent fuel storage racks described in Chapter 9 of the FSAR Update (Ref. 7). The affected structural details are listed in Section 1 and described in detail in Section 2.

The original racks, designed by PG&E using a standard Westinghouse design, were fabricated by LAMCO Industries Inc. and installed in 1974. In 1978 it was verified that the racks met the design requirements of the Hosgri earthquake.

In preparation for reinstalling the original racks, the licensee re-evaluated them as modified for reinstallation into the Unit 1 pool. The licensee and the staff met on September 10, 1986 (Ref. 5) and September 19-23, 1986 (Ref. 6) to discuss the changes and to audit the related design calculations. PG&E provided additional information in letters dated September 17, 1986 (Ref. 8) and September 23, 1986 (Ref. 9).

The licensee performed an evaluation of the modified racks and the anchorages to the spent fuel pool floor based on appropriate material properties, as-built configurations, and a more conservative dynamic rack behavior. This Section presents the staff evaluation of the changes.

5.2 FSAR Acceptance Criteria

The structural components associated with the fuel racks are classified as Design Class I and are designed to remain functional in the event that a Design Earthquake (DE), Double Design Earthquake (DDE), or the postulated Hosgri Earthquake (HE) occurs. The spent fuel pool liner is classified as Design Class II.

All materials which are in contact with the spent fuel pool water are fabricated using compatible stainless steel material. The spent fuel storage racks are designed in conformance with Safety Guide 13 (Ref. 11) and the American Institute of Steel Construction (AISC) Specifications for the Design Fabrication and Erection of Structural Steel for Buildings (Ref. 12). The American Society of Mechanical Engineers Boiler and Pressure Vessel Code (Ref. 13) is used by the licensee to establish allowable limits for materials not addressed by the AISC Specification.

The Quality Assurance and Quality Control Programs applied to the activity are those identified by the licensee in Chapter 17 of the FSAR (Ref. 7) which include the Commission's requirements of 10 CFR Part 50 Appendix B.

The racks are designed to withstand a vertical uplift force of 4000 pounds corresponding to a postulated event of a fuel assembly binding in the rack while being lifted by the spent fuel bridge crane.

5.3 Applicable Design Codes and Standards

The following design and material codes were utilized in the reanalysis, as applicable:

a. Specification for the Design, Fabrication and Erection of Structural Steel for Buildings, Feb. 12, 1969, American Institute of Steel Construction (AISC) (Ref. 12).

b. ASME Boiler and Pressure Vessel Code, Section III, July 1, 1983, American Society of Mechanical Engineers (Ref. 13).

c. Building Code Requirements for Reinforced Concrete, ACI 318-63 (Ref. 14).

d. PG&E Design Criteria Memoranda DCM C-17, DCM C-25 (Ref. 15).

e. TRW Nelson Division Catalogue "Embedment Properties of Headed Studs, Design Data 10", 1977 (Ref. 16).

The above listed codes and standards are identical to those used in the original rack evaluation, except for use of the 1983 ASME Code, Item b above. The selection of the 1983 ASME Code over the 1968 version, which was committed to in the FSAR, was made to allow implementation of current welding and inspection requirements and controls. Use of the 1983 Code provides clarification and improved inspection acceptance criteria.

5.4 Material Properties

The material properties used to qualify the spent fuel racks and their anchorage connection to the spent fuel pool concrete floor are as follows:

a. Corrosion resistant steel:

ASTM A240, Type 304 CRES, F_y=30 ksi, F_{tu}=75 ksi (min. values)

b. Electrodes for CRES:

AWS Type E308 or E308L, F_{tu}=75 ksi (min. value)

c. Nelson Studs:

Properties as per Reference 7

d. Embed Plate:

ASTM A108-1015

e. Concrete:

f'_c =5000 psi (min. specified)

All metal and weld properties used in the licensee's calculations are modified, as appropriate, to account for the effect of higher than room design temperature. The licensee utilized allowable material and weld stresses based on average testing values, as was allowed by the FSAR criteria, rather than the minimum specified code values. However, the licensee chose to use no more than 10% above the minimum specified values for the racks to ensure a conservative design. The actual average 28-day compressive strength of 5650 psi was utilized for the concrete as permitted by the FSAR criteria.

5.5 Seismic Input and Basis

The fuel rack reanalysis was based on the loads developed by the postulated Hosgri earthquake for the 100 foot elevation of the auxiliary building at the Diablo Canyon Power Plant. Both translational and torsional response spectra were derived from the Hosgri earthquake, which were then used to generate the accelerations for the worst-case rack location in the spent fuel pool.

Dynamic models were developed by the licensee which demonstrated that the resonant frequency of the fuel rack was in the range of 6-8 Hz. The resonant frequency was primarily related to the bending mode of an individual interior fuel cell, and dependent on the rack size (i.e. 7 X 5 cells or 6 X 5 cells) and the excitation direction. In addition, all significant modal frequencies were computed to be less than 14 Hz. Since the horizontal acceleration peaks of the Hosgri spectra at elevation 100' were in the vicinity of frequencies of 4 and 11 Hz, the licensee chose to perform equivalent static analyses using the peak values of the HE for both horizontal directions. For the vertical direction, the rack was determined to be dynamically rigid, thus the zero-period acceleration (ZPA) was used.

The equivalent static analyses, which included finite-element computer solutions as well as engineering calculations, were based on 1-g loads. The resultant load and displacement data were then combined using the peak spectra factors for each horizontal direction, (i.e. North-South 1.45g and East-West 1.60g), and the ZPA of 0.50g for the vertical direction.

5.6 Method of Analysis

The spent fuel racks were, analyzed using three-dimensional linear elastic models.

For seismic inertia load evaluation of the racks, two basic structural finite element models were developed:

- Global Rack Model (see Figure 17 of Enclosure 3)
- Individual Cell Model (see Figure 16 of Enclosure 3)

The global rack model is a three-dimensional, beam and truss model representing the lateral force-resisting system of a fuel rack. The individual cell model is a three-dimensional beam type model in which the corner members and lacing bars of a typical interior cell are modeled with supports at the top and bottom of the cell. For the global model, the corner cells were modeled similarly to the interior cell; other exterior cells were modeled as elastic beams with equivalent stiffness properties determined from the individual cell analysis; and the interior cells were modeled as an elastic beam with a combined stiffness value equal to the number of interior cells multiplied by the stiffness of each cell. Two additional finite element models representing the upper and lower diaphragms were developed to evaluate internal stresses as well as to determine maximum displacements at the top of the rack. The modeling characteristics of the above mentioned models are summarized in Reference 9, Table 1, Section III. Equivalent static analyses were performed using the models described above to evaluate the adequacy of key members and welded connections of the rack, and the embedment plates to which anchor brackets of spent fuel racks are welded.

The load paths due to the revised anchorage were evaluated and it was determined that welded connections between anchor brackets and floor embedded plates do not change the global load path, since the behavior of the rack module as a truss remains unchanged. However, these welded connections do indeed change the local load path on the embeds. The embeds were evaluated based on consideration of applicable loads, including the effect due to the change in the local path. The results are listed in Table 1 of Enclosure 3.

5.7 Conservatism in Analysis

The equivalent static analysis method as employed by the licensee has the following conservatisms in its application, which would tend to overstate the anchorage loads:

- The peak of the response spectra corresponding to the fundamental mode was used to accelerate the entire mass of the structure.
- The accelerations used for design were based on summing absolutely the broadened spectral response for translation and torsion, without accounting for possible random phasing, which could tend to reduce the seismic response.
- The fuel cells with somewhat different support conditions, attachment and with different mass distribution will tend not to vibrate in phase.

Other conservative assumptions made by the licensee also tend to overstate the anchorage loads, including:

- Friction carrying capacity at the base of each cell was ignored; thus all the shearing forces were supported by the anchorages.
- The fully loaded and largest rack (5 X 7 cells) was considered in all analyses. This conservative assumption also tended to compute larger member and joint stresses.

Various section and material conservative assumptions were used that would tend to result in larger response stresses and define smaller allowable stresses.

- The joint evaluations were based on worst-case as-built or design weld sizes.

- Some of the welds on the racks were ignored for simplicity of calculation.

- The allowable stress for the stainless steel structural members could have been computed as 20% over minimum, based on testing; only 10% over minimum was used.

5.8 Forces and Displacements

The independent equivalent static analyses of the fuel rack computed internal forces and moments for the modeled interior members and joints and the reactions at the modeled support points. Displacements and rotation at the joints were also computed. The deflection at the top corner of the rack was derived from the global rack model. The horizontal deflection at the center of the top of the rack was derived by superimposing the results from the detailed top diaphragm model with the global rack model. These deflections (Table 1, Section II of Enclosure 3) are significantly smaller than half the clearance provided between adjacent racks.

The reactions and rotation at the modeled support points were used to evaluate the adequacy of the lower rack corner, the welds to the anchor brackets, the anchor brackets, the welds to the embed plates, the embed plates, the studs, the concrete, and the liner adjacent to the embed plates. The maximum reactions and internal forces were determined from computer analysis for each earthquake direction. These were combined in accordance with acceptable procedures. These data and procedures were used in deriving a stress table. (See Table 1 of Enclosure 3).

5.9 Results for Key Elements

The licensee has prepared a Design Summary of Changed Racks (see Table 1 of Enclosure 3). The design summary provided, in a tabular form for all key structural components, the calculated stress or interaction stress ratio and compared each computed value to applicable FSAR Criteria allowables. In addition, the licensee indicated whether the FSAR criteria were met for each component. The key components are identified in Figures 2 through 12 of Enclosure 3.

The major structural components evaluated by the staff include the racks, the anchor brackets, the welds, the embedded plates, and the liner.

In the evaluation of the racks, the key items include the horizontal and diagonal bracing, the corner and interior angles, the lacing for each cell structure, and the top and bottom diaphram gridwork.

The welds have been evaluated at all key connections. These locations include the connection of the anchor brackets to the embedded plates and the racks, the connections of the splicing diagonal bars, and the repaired lacing for one cell in Rack 1.

The embedded plates have been evaluated for their bending response to rack loads, for the interaction of the Nelson studs with the stainless steel embedded plate and the concrete pool floor, and the controlling bearing response of the supporting concrete to the maximum postulated load.

Table 1, Section I of Enclosure 3 provides the results computed by the licensee and audited by the staff and consultants. In all cases the calculated values are less than the allowable values identified by the FSAR criteria.

5.10 Conclusions

The staff and consultants have reviewed the FSAR commitments and the detailed analyses utilized by the licensee for modifying the design, construction and fabrication of the structural components associated with the low density spent fuel racks for Diablo Canyon Unit 1. Based on this review and a detailed audit of the supporting calculations; the staff and consultants conclude that the changes to the low density spent fuel racks have not affected their capability to meet the original FSAR criteria. Therefore, we conclude that the low density spent fuel racks will maintain their structural integrity and function safety under the all specified loads.

6.0 EVALUATION OF AS-BUILT WELDS

The NRC Region V Resident Inspectors at the Diablo Canyon Plant examined the accuracy of the spent fuel rack as-built drawings generated by the licensee and used in the structural analysis by the licensee and audited by the NRR staff as discussed in Section 5. The inspection identified a few instances where the actual length of a weld is less than that recorded on the as-built drawings. The Region V Office requested that NRR evaluate the technical adequacy of these welds (Ref. 17). Details of the Region V inspection will be provided in an inspection report (Ref. 10).

The NRC resident inspector examined the accuracy of the as-built drawings of the spent fuel racks. Initially 64 welds on Racks 5 and 6 were randomly selected and inspected. Two welds were found to be less than recorded on the as-built drawings, including allowance for normal measurement tolerance. Subsequently, all 106 structural weld connections on the west face of Rack 2 were inspected. In only one case was the actual weld, as measured by the NRC Resident Inspectors and witnessed by the licensee, shorter than the recorded length, including allowance for normal measurement tolerances.

The NRR staff discussed the three welds (2 welds in initial sample of 64, 1 weld in second sample of 106) in a telephone call with the licensee on September 26, 1986 and requested additional information regarding (1) the details of the three welds (rack, location, description, analysis), and (2) the adequacy of the sample size. The licensee provided further information regarding item (1) above in a letter dated September 26 (Ref. 18). The details were discussed in a telephone discussion and audit of specific calculations on September 26. During the audit the licensee also provided information regarding the sample size (item 2 above). This information will be included in the staff's summary of this discussion (Ref. 19). The three welds under consideration are as follows:

1. Rack 2: The length of one original weld between a cross brace and a gusset plate at the cross brace intersection was recorded on the as-built drawing as 2 inches in length; the as-measured length is 1-5/8 inches. The location is shown on Figure 10 of Enclosure 3.

2. Rack 5: The length of one original weld between a mid-height gusset plate and the angle of a corner fuel cell was recorded on the as-built drawing as 9-1/2 inches in length; the as-measured length is 8-1/4 inches. The location is shown on Figure 3 of Enclosure 3.

3. Rack 6: The length of one original weld between a gusset plate at the bottom of the rack and a cross brace was recorded on the as-built drawing as 3-1/2 inches; the as-measured length is 3 inches. The location is shown on Figure 11 of Enclosure 3.

The licensee has evaluated the load bearing capacity of the three welds using the as-measured dimensions and concluded that in all three cases the welds in their current configuration are adequate (see Table 1 of Enclosure 3). The staff has reviewed the information provided by the licensee (Ref. 18; Enclosure 3), and also audited details of the design calculation packages (Ref. 19). Based on its review of these welds in their as-measured configuration the staff concludes that they provide adequate capacity to carry the design loads.

With respect to the adequacy of the sample size used in the evaluation of potential as-built weld discrepancies, the licensee calculated the probability of having 3 weld segment deviations in the sample of the 170 weld segments based on a binomial distribution, to assess if the criterion of no more than 5% weld deficiency at the 95% confidence level is met. The licensee concluded that the 3 deviations in weld size out of the 170 welds examined met the criterion which is widely accepted in the nuclear industry.

The staff has reviewed the information provided by the licensee and finds it acceptable. In addition, as stated above all of the three welds in their as-measured configuration are acceptable. The staff concludes that the original welds of the spent fuel racks are acceptable.

7.0 SUMMARY AND CONCLUSIONS

The staff has completed its evaluation of the design changes made to the Unit 1 original spent fuel racks, including changes in the method of reinstalling the racks into the Unit 1 spent fuel pool, and of the as-measured weld configuration. The staff evaluation was directed to ensure that original design criteria continue to be met and that the changes were made consistent with the regulations of 10 CFR 50.59. The staff evaluation included consideration of information provided by the licensee in submittals and during meetings, inspections and audits.

Based on its evaluation the staff concludes that the changes made to the original racks, the reinstallation of these racks and the original welds meet the original criteria and are capable to perform their safety function.
In particular, the staff concludes that the method of reinstallation by welding

the racks directly to the embed plates, instead of the original installation by using bolts that were welded to the embed plates, does not involve an unreviewed safety question as defined in 10 CFR 50.59. The staff concludes that the re-installation of the original spent fuel racks into Unit 1 pool, as described by the licensee is acceptable.

Dated October 3, 1986.

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